

AEROSPACE GUIDANCE AND METROLOGY CENTER (AGMC)  
Inertial Navigation/Calibration/Precise Time and Frequency Capabilities

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ABSTRACT

The Aerospace Guidance and Metrology Center was conceived in 1959 to be the US Air Force Inertial Navigation and Metrology Center. This paper will show the mission capabilities of the Inertial Navigation Maintenance Center and the Air Force Measurement and Standards Laboratory. Highlighted will be the precise time and frequency program developed by AGMC to support Air Force precise time and frequency requirements worldwide. A description of the past, present, and future precise time and frequency activities will be presented.

This paper is not intended as a technical presentation, but as a discussion of the US Air Force capabilities at Newark AFS. It's important to note that Newark AFS is located in Newark, Ohio, not Newark, New Jersey, as is often thought.

As you can tell from the name Aerospace Guidance and Metrology Center (AGMC), the mission at Newark AFS is twofold. One is the Inertial Guidance or Inertial Navigation mission and the other is the Air Force Metrology Center.

First, we will briefly tell you a little about what is referred to as the inertial navigation side of the house. Most of the 2600 or so people who work at AGMC are involved with the diagnostic testing, overhaul, repair, and checkout of inertial guidance systems for missiles and inertial navigation units for aircraft. This is a highly specialized career field and one of the reasons that Newark Air Force Station is unique.

The Missile Inertial Guidance System workload in the past included the Atlas and Titan, along with the current Minuteman System. Aircraft Inertial Navigation Systems serviced at AGMC include the A-7, F-4, F-111, and the C-5A.

The other unique mission at Newark Air Force Station is the Air Force Metrology Center. As you probably know, metrology is the science of measurement and in general, we are talking about calibration. The number of personnel assigned to the Metrology Directorate at AGMC is only about 220. However, a lot of responsibility is involved. The Air Force Measurement and Standards Laboratory is located at AGMC with direct traceability to NBS and the USNO. The underground laboratory complex consists of four floors

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE <b>DEC 1982</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-1982 to 00-00-1982</b>	
4. TITLE AND SUBTITLE <b>Aerospace Guidance and Matrology Center (AGMC) Inertial Navigation/Calibration/Precise Time and Frequency Capabilities</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Aerospace Guidance and Matrology Center (AGMC),Newark ,OH,43055</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES <b>Proceedings of the Fourteenth Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting, Greenbelt, MD, 30 Nov - 2 Dec 1982</b>					
14. ABSTRACT <b>see report</b>					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>4</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

descending in a tier with the lowest level at a depth of 55 feet. The concrete walls enclosing the laboratory taper from 6 feet at ground level to 7 feet at bottom level. The floor at bottom level is 11 feet thick. This large mass of concrete provides excellent thermal stability and vibration damping necessary for a laboratory performing state-of-the-art measurements. The standards at AGMC are used to calibrate the Air Force Base Standards in precision measurement equipment laboratories (PMELs) located throughout the world. Major measurement areas at AGMC include force, temperature, pressure, vibration, sound, vacuum, flow, mass, dimensional, optics, DC, low frequency RF, microwave, infrared, laser, and precise time and frequency.

This brings us to the major portion of this paper, the Precise Time and Frequency Program at AGMC. In the 1960s, most PMELs had frequency calibration requirements; for example, oscillators in frequency counters, but very few, if any, precise time requirements. Several Air Force activities had timing requirements, such as the Baker Nunn sites, Satellite Control Facility sites, and one or two classified precise time users. Rather than having precise time available in the PMELs, time was supplied to Air Force activities worldwide directly from AGMC utilizing two person clock teams. In the beginning, civilians were utilized, but today trained military personnel perform most portable clock timing requirements. A two week precise time-keeping school has been established by the United States Air Force Air Training Command, Lowry AFB, Colorado. All military and civilian personnel must attend this training prior to assuming timekeeping duties.

Our Precise Time and Time Interval (PTTI) program has been quite successful using the Hewlett-Packard E21-5061A Flying Clock, the Frequency Time Systems 4010 Light Weight Clock, and the Austron 1210 Crystal Clock. As more precise time requirements evolved, the expense of portable clock trips became prohibitive.

Alternate methods of providing precise time had to be developed. One method being applied is self-sufficiency where the user buys equipment and takes care of his own timing requirements. Examples of this would be TV Line-10, Loran-C, and various satellite timing receivers. Another method being utilized is to establish additional sources of precise time in certain geographical areas. Examples of this are the timing centers for the Eastern and Western Test Ranges, the Precise Time Reference Station at Elmendorf, Alaska, and the Precise Time and Frequency Consoles (PTFC) placed in certain PMELs. The PTFC provides an inexpensive timekeeping system that allows a trained technician to maintain and provide time service to selected AF users. Currently 26 PTFC systems are located strategically throughout the Air Force's approximately 129 Precision Measurement Equipment Laboratories.

Most Air Force precise time users require 100 microsecond timing accuracy. As a result, very few field sites are supported directly from AGMC today. Looking toward the future, we envision more self-sufficiency and more utilization of satellite timing methods.

Well, as you have probably noticed, not much has been said about frequency capability. In the 1960s, each Air Force PMEL was supplied with a VLF frequency comparator. This scheme worked quite well until the Navy VLF stations switched to (minimum shift keying) MSK. A few MSK converters were purchased and sent to labs who were totally dependent on those VLF stations; however, a lot of locations still seemed to have reception problems and it became difficult to determine if it was personnel problems or equipment problems for two reasons:

- a. The decline of expertise of PMEL technicians.
- b. The VLF receivers were getting very old, unreliable, and difficult to keep in repair.

Currently we are in the process of replacing the old VLF frequency comparator receivers with the new automatic Loran-C frequency monitors.

We have addressed the AGMC support of Air Force precise time and frequency requirements and have only one final aspect to cover. Just a few years back, it was determined that the cost of maintaining Air Force atomic standards was quite high. A feasibility comparison study was conducted and the decision was made to establish a Technology Repair Center (TRC) within the Maintenance Directorate. The TRC is responsible for repair and calibration of atomic standards. A large bench stock of components, cesium and rubidium tubes, and trained electronic technicians allow our TRC to provide quality repair and calibration service with a quick turnaround to all customers. Presently we provide repair service by Memorandum of Agreement (MOA) to Baker-Nunn, Satellite Control and Communication facilities, and other DOD agencies. Any DOD agency wishing to use our services should contact the appropriate AGMC office.

In summary, AGMC has a dynamic viable Precise Time and Frequency program that can provide repair service and portable clock timing to approved customers. We provide 0.5 microseconds time transfers at AGMC, 1 microsecond for trips less than 5 days, and at all other times, 2 microseconds. We encourage consultation with AGMC on any time/frequency requirement that you may have.

## QUESTIONS AND ANSWERS

DR. COATES:

Questions? Yes?

MR. MIKE GARVEY, FTS

I'd like to comment at the risk of sounding overly commercial. FTS now manufactures the satellite receiver which you showed. The performance of this system is currently limited by the update maintenance capabilities of the Navy. And, I have had some discussions. I think very properly so, with people here at this meeting who realize the potential of this service and the importance of a proper maintenance of that. I think your evaluation of a few hundred microseconds is certainly within the realm of possibility, but I don't think it's customarily quite that large.

MR. GALLOWAY:

Yes. I am completely with agreement of that. We realize that the filter factor of this can resolve that to a number quite smaller than that. But typically, we send this particular instrument to a location and allow it to remain on site approximately five days.

So, in general, we're using Quartz type reference frequency and as you know, with the instrument, the reference frequency can be a major error, so that's the reason. And the truth, if you'd like to be very specific about the number, we believe that we can do a bit less than fifty. Twenty-five is about what we like to talk about.

DR. COATES:

Thank you, Larry.